



400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard



AMS 5856B

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Superseding AMS 5856A

Alloy Billets and Preforms, Corrosion and Heat Resistant
59.5Ni - 12Cr - 10Co - 3.0M - 6.0W - 3.0Ti - 1.5Ta - 4.5Al - 0.015B - 0.10Zr
(0.30 - 0.35C), Powder-Metallurgy Product

UNS N07012

CANCELLATION NOTICE

This specification has been "CANCELLED" by the Aerospace Materials Division, SAE, as of October 1998. By this action, this document will remain listed in the Numerical Section of the Index of Aerospace Material Specifications.

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1. SCOPE:

1.1 Form:

This specification covers a corrosion and heat resistant nickel alloy powder-metallurgy product in the form of billets and preforms the forgings.

1.2 Application:

Primarily for parts requiring high strength up to 1500°F (815°C) and corrosion and oxidation resistance up to 1700°F (925°C).

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2261 Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars and Forging Stock
AMS 2269 Chemical Check Analysis Limits, Wrought Nickel Alloys and Cobalt Alloys
AMS 2350 Standards and Test Methods
AMS 2375 Control of Forgings Requiring First Article Approval
AMS 2630 Ultrasonic Inspection
AMS 5855 Alloy Powder, Corrosion and Heat Resistant, 59.5Ni - 12Cr - 10Co - 3.0Mo - 6.0W - 3.0Ti - 1.5Ta - 4.5Al - 0.015B - 0.10Zr (0.30 - 0.35C)

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 8 Tension Testing of Metallic Materials
ASTM E 10 Brinell Hardness of Metallic Materials
ASTM E 21 Elevated Temperature Tension Tests of Metallic Materials
ASTM E 112 Estimating the Average Grain Size of Metals
ASTM E 139 Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E 292 Conducting Time-for-Rupture Notch Tension Tests of Materials
ASTM E 354 Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

FED-STD-151 Metals: Test Methods

MIL-STD-163 Steel Mill Products - Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Material:

Billets and preforms shall be produced by consolidation of AMS 5855 powder by a process which will produce a product meeting the requirements of 3.2, 3.5, and 3.6.

3.2 Composition:

Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E 354, by spectrographic methods in accordance with FED-STD-151, Method 112, except that oxygen and nitrogen shall be determined by Leco Gas Analyzer, or by other analytical methods approved by purchaser:

3.2.1 Check Analysis: Composition variations shall meet the requirements of AMS 2269.

3.3 Condition:

As ordered by the forging manufacturer.

3.4 Heat Treatment:

When specified, the product shall be heat treated as follows:

3.4.1 Solution Heat Treatment: Heat to a temperature within the range 2175 ° - 2225°F (1190 ° - 1220 °C), hold at the selected temperature within $\pm 15^\circ\text{F}$ ($\pm 8^\circ\text{C}$) for 2 hr ± 0.3 , and quench in oil.

3.4.2 Stabilization Heat Treatment: Heat to 2050 °F ± 15 (1120 °C ± 8), hold at heat for 2 hr ± 0.3 , and cool in air to below 700 °F (370 °C).

	min	max
Carbon	0.30	0.35
Manganese	-	0.10
Silicon	-	0.10
Phosphorous	-	0.015
Sulfur	-	0.015
Chromium	11.50	12.50
Cobalt	9.50	10.50
Molybdenum	2.50	3.50
Tungsten	5.50	6.50
Titanium	2.75	3.25
Tantalum	1.00	2.00
Aluminum	4.20	4.80
Boron	0.01	0.02
Zirconium	0.05	0.15
Iron	-	1.00
Lead	-	0.0002 (2 ppm)
Bismuth	-	0.00005 (0.5 ppm)
Oxygen	-	0.010 (100 ppm)
Nitrogen	-	0.005 (50 ppm)
Nickel	remainder	

3.4.3 Precipitation Heat Treatment: Heat to 1300 °F ± 15 (705 °C ± 8), hold at heat for 12 hr ± 0.5, cool in air to below 700 °F (370 °C), reheat to 1500 °F ± 15 (815 °C ± 8), hold at heat for 8 hr ± 0.5, and cool in air.

3.5 Properties:

When specified, a sample billet or preform shall be forged to a test coupon and heat treated as in 3.4; specimens taken from the heat treated coupon shall conform to the requirements of 3.5.1 through 3.5.5. If specimens taken from billets or preforms after heat treatment as in 3.4 conform to the requirements of 3.5.1 through 3.5.5, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5.1 Grain Size: Shall be predominantly recrystallized grains of 1 or finer with no segregation of coarse or fine areas, determined by comparison of a polished and etched specimen with the chart in ASTM E 112.

3.5.2 Tensile Properties: Shall be as follows for forged coupons, billets, or preforms 4.0 in. (100 mm) and under in nominal cross-section; tensile property requirements for billets or preforms over 4.0 in. (100 mm) in nominal cross-section shall be as agreed upon by purchaser and vendor. Property requirements of 3.5.2.1 and 3.5.2.2 apply to both longitudinal and transverse directions unless direction of specimen orientation is specified by purchaser.

3.5.2.1 At Room Temperature: Shall be as follows, determined in accordance with ASTM E 8:

Tensile Strength, min	190,000 psi (1310 MPa)
Yield Strength at 0.2% Offset, min	140,000 psi (965 MPa)
Elongation in 4D, min	10%
Reduction of Area, min	12%

3.5.2.2 At 1500 °F (815 °C): Shall be as follows, determined in accordance with ASTM E 21 on specimens heated to 1500 °F ± 10 (815 °C ± 5), held at heat for 20 - 30 min. before testing, and tested at 1500 °F ± 10 (815 °C ± 5):

Tensile Strength, min	150,000 psi (1035 MPa)
Yield Strength at 0.2% Offset, min	125,000 psi (860 MPa)
Elongation in 4D, min	10%
Reduction of Area, min	12%

3.5.3 Hardness Should be 321 - 415 HB or equivalent, determined in accordance with ASTM E 10, but the product shall not be rejected on the basis of hardness if the tensile property requirements of 3.5.2.1 are met.

3.5.4 Stress-Rupture Properties at 1500 °F (815 °C): Shall be as follows; testing of notched specimens and of combination smooth-and-notched specimens shall be in accordance with ASTM E 292 and of smooth specimens in accordance with ASTM E 139:

3.5.4.1 A combination smooth-and-notched specimen machined to the dimensions shown in Figure 1 and Table I, maintained at 1500 °F ± 3 (815 °C ± 2) while a load sufficient to produce an initial axial stress of 80,000 psi (550 MPa) is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. After the 23 hr, if rupture occurs in the notch, the smooth section shall, by suitable means, be continued to rupture or a separate smooth specimen shall be tested to rupture under the above conditions. Elongation of the smooth section after rupture, measured at room temperature, shall be not less than 5% in 4D.

3.5.4.2 As an alternate procedure, separate smooth and notched specimens, machined from adjacent sections of the same piece with gage sections conforming to the respective dimensions of Table I, may be tested individually under the conditions of 3.5.4.1. The smooth specimen shall not rupture in less than 23 hr and elongation after rupture, measured at room temperature, shall be not less than 5% in 4D. The notched specimen shall not rupture in less than 23 hr but need not be tested to rupture.

- 3.5.4.3 The tests of 3.5.4.1 and 3.5.4.2 may be conducted using a load higher than required to produce an initial axial stress of 80,000 psi (550 MPa) but load shall not be changed while test is in progress. Time to rupture and elongation requirements shall be as specified in 3.5.4.1.
- 3.5.4.4 When permitted by purchaser, the tests of 3.5.4.1 and 3.5.4.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 80,000 psi (550 MPa) shall be used to rupture or for 23 hr, whichever occurs first. After the 23 hr and at intervals of 8 - 16 hr, preferably 8 - 10 hr, thereafter, the stress shall be increased in increments of 5000 psi (34.5 MPa). Time to rupture and elongation requirements shall be as specified in 3.5.4.1.
- 3.5.5 Creep Properties at 1400 °F (760 °C): A smooth tensile specimen shall be maintained at 1400 °F \pm 3 (760 °C \pm 2) while a load sufficient to produce an initial axial stress of 70,000 psi (480 MPa) is applied continuously for 100 hr or until 0.2% plastic strain is produced, whichever is longer. The plastic strain after 100 hr and the time to 0.1% and 0.2% plastic strain shall be reported. Gage dimensions of specimens and techniques used to measure creep shall be as agreed upon by purchaser and vendor. Tests shall be conducted in accordance with ASTM E 139.
- 3.6 Quality:
- The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from internal and external imperfections detrimental to usage of the product.
- 3.6.1 Preforms shall have substantially uniform macrostructure and grain flow. Standards for acceptance shall be as agreed upon by purchaser and vendor.
- 3.6.2 Billets and preforms shall be ultrasonically inspected in accordance with AMS 2630. Method of test and standards for acceptance shall be as agreed upon by purchaser and vendor.
- 3.7 Tolerances:
- Unless otherwise specified, tolerances for billets shall conform to all applicable requirements of AMS 2261.
4. QUALITY ASSURANCE PROVISIONS:
- 4.1 Responsibility for Inspection:
- The vendor of the product shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

- 4.2.1 Acceptance Tests: Tests to determine conformance to requirements for composition (3.1), ultrasonic quality (3.6.2), tolerances (3.7), and, when specified, grain size (3.5.1), tensile properties (3.5.2), hardness (3.5.3), stress-rupture properties (3.5.4), and creep properties (3.5.5) are classified as acceptance tests and shall be performed on each lot.
- 4.2.2 Periodic Tests: Tests to determine conformance to property (3.5) requirements are classified as periodic tests, except when purchaser specifies that such tests are acceptance tests, and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.
- 4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed on the first-article shipment of the product to a purchaser, when a change in material or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.
- 4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling:

Shall be as agreed upon by purchaser and vendor except as specified in 4.3.1; a lot shall be all product produced from one powder lot in one continuous production run and presented for vendor's inspection at one time.

- 4.3.1 Each billet and preform shall be ultrasonically inspected.

4.4 Approval:

- 4.4.1 Preproduction compactions of powder into billets or preforms shall be approved by purchaser before billets or preforms for production use are supplied, unless such approval be waived by purchaser. Approval of preproduction billets and preforms shall in no way relieve the billet or preform vendor of responsibility for continued performance to all purchase order requirements.
- 4.4.2 The vendor shall establish for each size of billet and for preforms of each configuration parameters for the control factors of processing which will yield products meeting the requirements of this specification. These shall constitute the approved manufacturing procedures for each product and shall be used for subsequent production of the product. If necessary to make any change in parameters for the control factors of processing, vendor shall submit for reapproval a statement of the proposed changes in materials and/or processing and, when requested, sample product. Production product incorporating the revised operations shall not be shipped prior to receipt of reapproval.

4.4.2.1 Control factors for producing the product include, but are not limited to, the following:

Source of metallurgical powder
Type of compaction equipment
Processing sequence or number of operations, including thermal operations, that would result in different cross sectional structure, grain flow, or working of the metal
Protective atmosphere
Cleaning operations (e.g., chemical descaling or mechanical cleaning)
Inspection and testing

4.4.2.1.1 Any of the above control factors of processing for which parameters are considered proprietary by the vendor may be assigned a code designation. Each variation in such parameters shall be assigned a modified code designation. The vendor shall maintain complete records of all proprietary processes and factors.

4.5 Reports:

4.5.1 The vendor of the product shall furnish with each shipment three copies of a report showing the results of tests for chemical composition of each lot and, when specified, the results of tests to determine conformance to the other acceptance test requirements of this specification. This report shall include the purchase order number, AMS 5856A, lot number, size of billet or part number of preform, quantity, and the source and lot number of powder used to make the billets or preforms.

4.5.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, AMS 5856A, contractor or other direct supplier of material, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.6 Resampling and Retesting:

If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Identification:

Shall be as agreed upon by purchaser and vendor.